RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
IOWA STATE UNIVERSITY / AMES, IOWA

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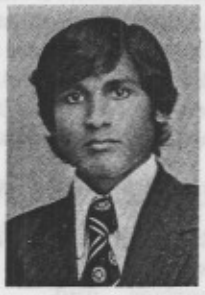
RARE EARTH RESEARCH IN INDIA


M. N. Viswanathiah


J. A. K. Tareen


P. N. Satish


T. R. N. Kutty


K. V. Krishnamurthy


N. Rao

University of Mysore—

Rare earth research was initiated in the hydrothermal laboratory of the Mineralogical Institute, University of Mysore, Mysore-570 006 India in 1973, under the leadership of Prof. M. V. Viswanathiah, Director of the Mineralogical Institute, in collaboration with the Inorganic and Physical Chemistry Laboratory, Indian Institute of Science, Bangalore. The first study was on the hydrothermal equilibria in lanthanide oxide-water systems and stabilization of the different rare earth oxides, oxyhydroxides and trihydroxides. In this study the basic P-T diagrams for all the R_2O_3-H_2O systems were established and it was found that only the oxides of heavier lanthanides (Er, Tm, Yb, Lu) are stable. This study also proved that impurities such as Na^+, NO_3 and CO_2 could be used as potential mineralizers as well as agents to bring down the temperature of equilibrium, and that cubic lanthanide oxide crystals could be grown under hydrothermal conditions. The growth of cubic oxide crystals under different alkaline as well as acidic mineralizers showed that HNO_3 is both a good mineralizer and an oxidizing agent. The grown cubic lanthanide oxide crystals have an unusual fibrous morphology which is explained on the basis of topotactic transformation of fibrous Ln-hydroxynitrates.

Hydrothermal equilibria in the R_2O_3-H_2O-CO_2 systems for all the lanthanides has been taken up and the different lanthanide carbonates have been synthesized. These were found to be isostructural with the natural mineral equivalents like bastnaesite, ancylites, tengerite, and solid solution phases of ancylite and tengerite.

After completing our investigation of the stability range of the cubic lanthanide oxides, we are extending our studies in the following fields:

(a) Hydrothermal equilibria in R_2O_3-Co_2O_3-H_2O systems and preparation of different $RCoO_3$ phases, with the main object of preparing materials suitable as permanent magnets. We are attempting to study the growth of crystals both under alkaline (NaOH, KOH) and acidic (HNO_3) media.

(b) Hydrothermal equilibria in R_2O_3-Fe_2O_3-H_2O systems and the stability range of different ferrite and garnet structures.

(c) Hydrothermal preparation of mixed lanthanide oxides, particularly the lanthanide oxides of the yttria group doped with Ce^{4+} and Eu^{2+}, with the object of preparing semiconducting materials of both p- and n-type.

Dr. T. R. Narayanan Kutty from the Indian Institute of Science, Bangalore, who is now in the Department of Electrical Engineering, University of Dortmund, West Germany, is an active associate of our research group.

Although our laboratory is quite young, we have ambitious plans for expansion, and we are willing to enter into international collaborative research programs on any of the specific fields of present research.

X-ray Screens Tested

New horizons in rare earth x-ray intensifying screen technology were examined by researchers at a meeting held May 20, 1977 at the Middlesex Hospital Medical School, London, England. Abstracts of papers on image requirements, speed and noise properties, evaluation techniques, user experience and implications for the future appear in the *Brit. J. Radiol.* **51**, 233-6 (1978).

Sc

1879

Congratulations are in order for the 100th anniversary of the discovery of scandium by L. F. Nilson. Scandium's story actually began in 1871 when D. I. Mendeleev published his treatise "Fundamentals of Chemistry" in which several as yet undiscovered elements were predicted. One of these predictions was eka-boron, atomic weight 45. Eight years later in 1879, while attempting to isolate ytterbium from gadolinite and euxenite, L. F. Nilson obtained 0.35 grams of a new rare earth which had a molecular weight of less than 131. The new element was named scandium to honor Scandinavia where the minerals were found. Atomic weight tests later confirmed that scandium and eka-boron were one and the same giving credence to Mendeleev's proposed periodic law of the elements. Since that illustrious beginning scandium has led a rather sedated existence finding little practical importance so that even today it is hardly more than a laboratory curiosity. Commercial applications have included use as a radioisotope tracer in oil well drilling and analytical work and in high intensity lamps.

Superconductivity Conference

The third conference on superconductivity in *d*- and *f*- band metals will be held June 21-23, 1979 at the University of California, San Diego, LaJolla, California. The scope of the conference will be similar to the previous two conferences with primary emphasis on the basic physics of all relevant aspects of superconductivity in *d*- and *f*-band metals. There will be both invited and contributed papers and ample time for discussion. Parallel sessions will be avoided, if necessary, through the use of poster sessions. Contributors should send an abstract and a rough draft of their paper to Dr. J. K. Hulm, Westinghouse R & D Center, 1310 Beulah Road, Pittsburgh, PA 15235 by March 1, 1979. Authors of accepted papers will be notified by April 1, 1979.

EUCHEM Conferees

EUCHEM CONFERENCE

The Euchem Conference on the chemistry of the rare earths was held May 30-June. 2, 1978 at Espoo, near Helsinki, Finland. The Conference was sponsored by the Association of the Finnish Chemical Societies and attended by some 60 participants from 14 countries. The largest groups, outside the host country, came from France, Norway, Switzerland and Germany, but there were also some rare earth scientists from distant countries like the U. S., India and Iran. The early summer weather in Finland was favorable and the long, sunny days were enjoyed by the participants during and after the Conference.

The three topics discussed during the Conference included the systematics in the properties of the rare earths, coordination and complex formation, and nonmetallic rare earth materials. In each section there were three invited lectures and several short contributions from the participants. The total number of papers presented was 38 of which most were presented in the second section. There were many lively discussions during the conference, particularly concerning the systematics of rare earths. The proceedings of the Conference will not be published, however, some articles based on the plenary lectures have appeared in the Finnish chemical journal *Kemia-Kemi* **5**, [6] (1978).

Coordination Chemistry Review

A review devoted to the advances in the synthesis and study of the physicochemical properties and structure of lanthanide complexes achieved during the 1965-1975 period has been published by V. T. Panyushkin, Yu. A. Afanas'ev, A. D. Garnovskii and O. A. Osipov [*Uspekhi Khimii* **46**, 2105-38 (1977); Engl. Transl.-*Russ. Chem. Rev.* **46**, 1109-31 (1977)]. The topics covered are the characteristics of the complex formation reactions, synthesis of coordination compounds, thermodynamics of complex compounds, investigation of the molecular structures of the complexes and spectroscopic studies including fluorescence, absorption, infrared and microwave spectra. A systematic account is given of data mostly for organic oxygen- and nitrogen-containing ligands. Emphasis is focused on the application of the physical and physicochemical research techniques in the chemistry of lanthanide complexes. 484 references are cited.

Management Change for Indian Rare Earths, Ltd.

Indian Rare Earths, Ltd. has announced the appointment of Mr. M. A. Hadi as chairman and Managing Director following the retirement of Mr. N. D. Hansotia.

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Bernie Evans...Staff Writer

LETTER

To the Editor:

The desire to reserve the symbols Pr and Ac solely as element symbols [F. Weigel, *RIC News* **XIII,** [3] 2 (1978)] is commendable but not practical. When praseodymium and actinium were discovered (1885 and 1899, respectively), the symbols Pr and Ac were already in common use along with Me, Et, Bz, etc. as symbols for radicals (see the abstract section of *J. Chem. Soc.* for 1884). Nomenclature in science is very much dependent upon priority of use and it was those who named these elements who created the duality of usage.

The IUPAC commission on the Nomenclature of Inorganic Chemistry "assumed" the role of approving names and symbols for newly discovered elements (1946-57) in the course of its efforts to express a preference in those cases where two names with corresponding symbols were being used for the same element. The corresponding commission for organic chemistry historically has not sought to develop new nomenclature but to codify existing practice. IUPAC through its Interdivisional Committee on Nomenclature and Symbols seeks to avoid conflicts in any new recommendations that it approves. However, it has not undertaken to adjudicate long standing inconsistencies. Further, the only bodies with power to enforce nomenclature restrictions are national rather than international in scope.

W. Conrad Fernelius
Kent State University
Kent, Ohio 44242

New Mössbauer Journal

A new journal entitled *Mössbauer Effect Reference and Data Journal,* edited by J. G. Stevens, V. E. Stevens and W. L. Gettys, has been initiated to aid researchers in locating Mössbauer references in other scientific journals. Each issue includes the reference listing, indexes for data, isotopes and subject material, a list of the authors' names and addresses, news of meetings of interest and occasionally an article written specifically for those researchers using the Mössbauer effect technique who are limited by time, experience and/or money and facilities. There are ten issues per volume and an index issue which contains the compiled reference listing for the entire volume. The Journal is available directly from the Mössbauer Effect Data Center. For additional information contact:

William L. Gettys
Mössbauer Effect Data Center
University of North Carolina
Asheville, NC 28804

4th RE-Co Workshop

The Fourth International Workshop on Rare Earth Cobalt (RE-Co) Permanent Magnets and Their Applications will be held May 22-24, 1979 at the Hakone Prince Hotel, International Conference Room, Hakone National Park near Tokyo in Japan. The program will include oral presentations and panel discussions of invited and contributed papers and possibly some poster sessions. Tentative subjects include theories and properties of RE-Co compounds and alloys, resources and refining of rare earth elements, materials for RE-Co magnets, and applications of RE-Co magnets including electronic, mechanical, medical and other new applications. A limited amount of space will be available for companies and organizations who wish to exhibit hardware or informational items. Interested parties should contact Mr. Kurino whose address is given below. Technical tours and a ladies program are also planned.

The number of participants is limited to 150 so register early. Payment of fees on or before February 28, 1979 receives a 10% discount. Registration and fees are 50,000 yen (U.S. $250) and includes a copy of the Proceedings, Program, Abstract Book and Reception fee.

For additional information contact either

Mr. T. Kurino, General Secretary
The Society of Non-Traditional Technology
Toranomon Kotohira Kaikan Bldg.
No. 2-8, 1-Chome, Toranomon,
Minato-ku, Tokyo
105 Japan,
or
Dr. Karl Strnat
2530 Ardath Court
LaJolla, CA 92037

Conduction Electron Theory

The theory of the coupling between conduction electrons and magnetic or electric moments of $3d$ and $4f$ ions has been reviewed by L. L. Hirst [*Advances in Physics* **27,** 231-85 (1978)] with emphasis on a systematic treatment of the generalized coupling forms. The present review is restricted to the spherically symmetric case and does not include crystal field effects. Included in the symmetry analysis of k - μ couplings are irreducible tensors, partial-wave basis states, charge screening, unit tensor operators, the k-f coupling in tensor form, time reversal symmetry, equivalences among ionic unit tensors, the total coupling strength, comparison with conventional coupling forms and the T-matrix in irreducible form. Direct and exchange Coulomb couplings are considered as well as the various aspects of virtual-mixing coupling including the basic coupling mechanism, coupling with and without intrinsic splitting effects and contributions from two-electron mixing. Areas for application of this theory suggested by the author are in the interpretation of the relaxation of ionic moments (from electron paramagnetic resonance, Mössbauer, inelastic neutron scattering from crystalline electric fields), transport phenomena and the general Kondo problem in metals doped with rare earths containing unpaired $4f$ electrons.

Absorbs More Water

Faster than a paper towel! More powerful than a sponge! Able to absorb large quantities of liquid in a short period of time! Is it Superman? No—it's Super Slurper!!! Who or what is Super Slurper? According to M. O. Weaver, R. R. Montgomery, L. D. Miller, V. E. Sohns, G. F. Fanta and W. M. Doane, it is a base hydrolyzed starch-polyacrylonitrile graft copolymer which can absorb 600 to 900 grams of distilled water per gram of the copolymer [*Die Stärke* **29,** [12] 410-3 (1977)]. Cerium in the form of ceric ammonium nitrate plays a key role in the preparation of Super Slurper as it initiates graft polymerization of the various constituents. Recognized in 1975 as an IR-100 winner, Super Slurper has many potential applications including disposable diapers, surgical sponges, and soil additives.

NINE MORE AID RIC

Eight companies have renewed their support of the Rare-Earth Information Center and another company joined them for the first time during the third quarter of the 1979 fiscal year. Adding the nine companies listed below brings the number of RIC benefactors to date up to thirty-nine. The number in parentheses following each company is the number of years that company has supported the Center.

Allied Chemical Corporation, U.S.A. (7),
Bose Corporation, U.S.A. (2),
British Flint and Cerium Manufacturers, England (7),
Companhia Industrial Fluminense, Brazil (7),
General Electric Company, U.S.A. (4),
GTE Laboratories, Inc., U.S.A. (7),
Industrial Minera Mexico, S.A. (5),
Lunex Company, U.S.A. (9),
Pokmen Company, Hong Kong (1).

WELD FILLER

Research by R. S. Brown and J. B. Koch of the Carpenter Technology Corporation has resulted in the development of a solidification crack resistant weld filler metal for a stabilized fully austenitic alloy [*Welding Journal* **57**, [2] 38s-42s (1978)]. Holding the plate thickness, groove configuration, filler metal dimensions, feed rate and welding parameters all constant, the composition of the weld filler alloy, ER 320, was varied to determine the effect of various alloy components upon cracking. The elements studied were Nb, Ce + La, Si, P and Mn. In the first four cases, reduction of the element concentration resulted in reduction in the amount of weld cracking. Reduction of Mn content resulted in increased weld cracking. Based on this and other evidence from fissure bend and corrosion tests, the authors developed an experimental alloy within the composition range of: 0.025% max. C, 1.5 - 2.0% Mn, 0.10% max. Si, 0.010% max. P, 0.005% max. S, 19.5 - 21.0% Cr, 33.0 - 35.0% Ni, 2.0 - 3.0% Mo, 3.0 - 3.5% Cu, 8 x C min. - 0.35% max. Nb and 0.01% max. Ce + La which exhibited superior solidification cracking resistance and equal intergranular corrosion resistance to that produced from the use of ER 320.

Optical Spectra Overview

In *Optical Spectra of Transparent Rare Earth Compounds,* S. Hufner offers an elementary treatment of the major areas in the field of the spectroscopy of transparent rare earth solids. Different chapters are devoted to free ions, trivalent ions in the static crystal field, trivalent rare earth ions in a phonon field, energy transfer, magnetic interactions, hyperfine interactions, Jahn-Teller systems, divalent rare earth compounds: the europium chalcogenides, rare earths in glasses and rare earth lasers. The underlying physics of selected examples are explained and theoretical results are applied for the interpretation of experimental data. The optical spectra of the rare earths in transparent solids have become important in the investigation of magnetism, the Jahn-Teller effect and mixed valence states and this monograph presents, from the experimentalist's viewpoint, a timely overview of the most important findings in these areas. Published by Academic Press, New York in 1978, the book is 256 pages long and costs $24.00.

MM Paper Available

A paper entitled "Trends in the Use of Mischmetal" has been presented by I. S. Hirschhorn at the American Society for Metal's Advisory Technical Awareness Council Meeting held in September 1978 in Cleveland, Ohio for the purpose of examining new and emerging technology in the 1980-1985 time frame. The paper discusses current mischmetal uses and predicts increased usage in the future in the production of continuous cast steel, free-machining steel and rare earth-cobalt permanent magnets. Copies of the paper are available from the Ronson Metals Corporation, 45-65 Manufacturers Place, Newark, NJ 07105, U.S.A.

1978 IR-100

Two rare earth applications cracked the top 100 list of significant new technical products of 1978 as determined by *Industrial Research/ Development* magazine [**20**, [10]107-8 (1978)]. A brief description of the two products, both of which come under the energy and power category, are given below.

Alloys of the general formula $Ca_{1-x}MM_xNi_5$ (MM = mischmetal) have been developed by G. Sandrock, of the International Nickel Company, which can absorb and desorb large quantities of hydrogen at room temperature and moderate pressure. When compared with compressed gas cylinders, these alloys use 25% of the volume, 75% of the weight and less than 10% of the pressure to store an equivalent amount of hydrogen. Other advantages are greater safety and ease of recharging. Possible applications include fuel storage for hydrogen powered vehicles and hydrogen purification systems.

G. V. Brown of NASA-Lewis Research Center has developed a high efficiency practical magnetic heat pump which uses gadolinium as the working fluid in a regenerative thermodynamic cycle [also see *RIC News* **XI**, [4] 3 (1976)]. His invention makes magnetic cooling possible over a broad temperature range including room temperature. Possible applications include liquefaction of air and natural gas.

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14th Rare Earth Research Conference

Less than a month from now many of you will be on your way to Fargo, North Dakota to participate in the Fourteenth Rare Earth Research Conference. A complete program has been arranged with both invited and contributed papers on the subjects of Spectroscopy, which includes luminescence, fluorescence, laser, Mössbauer and ESR; Metallurgy and Materials Preparation; Solution, Solvation and Analytical Chemistry; X-Ray and Neutron Diffraction; Transport and Thermal Properties; Hydrides; Magnetism; and Rare Earth Technology. The use of poster sessions has eliminated the need for concurrent oral sessions. The invited speakers and their topics are listed below.

W. E. Wallace, Plenary Address
F. Pobell, Spectroscopy
C. K. Jørgensen, Spectroscopy
K. A. Gschneidner, Jr., Metallurgy and Materials Preparation
G. R. Choppin, Solution, Solvation and Analytical Chemistry
E. Parthé, X-ray and Neutron Diffraction
E. F. Westrum, Jr., Transport and Thermal Properties
F. Hulliger, Hydrides
K. J. Strnat, Rare Earth Technology
F. Rothwarf, Rare Earth Technology
R. P. Turcotte, Rare Earth Technology
D. Givord, Magnetism

For those who have not yet registered there is still time. The $70 fee includes a copy of the proceedings, a ticket for the bison feed Tuesday evening and a ticket for the fish fry Wednesday evening. Of special note is the $10 registration fee for students (does not include a copy of the proceedings). Transportation will be provided from Fargo's Hector Airport to the conference site on the North Dakota State campus on Monday and back to the airport on Thursday.

Sooooo...if the creeks (Red River) don't rise (much further) we will see you all at Fargo!!

FIRST RARE EARTH PRIZE TO WALLACE

F. H. Spedding

W. E. Wallace

The selection committee has chosen to honor two outstanding rare earth scientists in the awarding of the first Rare Earth Prize at the opening of the Fourteenth Rare Earth Research Conference to be held June 25-28, 1979 at North Dakota State University, Fargo, North Dakota. The selection committee unanimously agreed that this honor should henceforth be called the "Frank H. Spedding Award." Citing Spedding's contributions of research and leadership in the rare earth field, the committee deemed his career, which has spanned over 50 years, to be the most outstanding model by which all others could be measured. Among his colleagues he is equally admired for the breadth of his scientific interest and wisdom, his unquenchable enthusiasm, his encouragement and friendly criticism, and for his dedication to science. Without his efforts, rare earth research, industry and technology could not have progressed to where they are today. Professor Spedding will be on hand to present the first Frank H. Spedding award to Professor W. E. Wallace of the University of Pittsburgh. Professor Wallace was chosen to be the first recipient of this award based on the testimony from many colleagues of international reputation of the many years of outstanding research and service he has given to the field of rare earth science and technology. The award cites his character, personality, sense of commitment, and intellect in providing both a model and a challenge to his students and colleagues alike. Immediately following the presentation at the opening session, Tuesday morning, Professor Wallace will give the plenary address.

Sm

1879

Samarium also claims 1879 as the year of its discovery which makes 1979 its 100th birthday. Like most of the rare earths, samarium's existence was suspected long before its actual discovery. In 1841 C. G. Mosander had treated lanthana with dilute nitric acid and separated a new rose-colored oxide which he named didymium. As early as 1853 J.-C. G. de Marignac believed that didymia was not a pure substance. Later spectroscopic studies of didymia by M. Delafontaine and L. de Boisbaudran showed a variation in the spectrum of didymia according to its source. In 1879 de Boisbaudran added ammonium hydroxide to didymia and observed a new oxide which precipitated before the didymia. De Boisbaudran observed that the spectrum of this new oxide was different from that of didymia and came to the conclusion that he had discovered a new element which he named samaria after a Russian mine official, Colonel M. Samarski.

LAST QUARTER

Contributions have been tallied for the 1979 fiscal year. With the receipt of contributions in the fourth quarter from the eight companies listed below, RIC ends out the year with a total of 46 benefactors, 44 sustaining members and two new companies. This year's total ties with last year's record total for the largest number of companies to come to the support of RIC. The number in parentheses indicates the number of years the company has contributed to the support of the Center.

Apache Chemicals, Inc., U.S.A. (3)
Colt Industries-Crucible Inc., U.S.A. (5)
Companhia Industrial Fluminense, Brazil (7)
GTE Sylvania Inc., U.S.A. (7)
Middlewest Investment Co., U.S.A. (1)
Nuclemon-Nuclebras de Monazita e Associados Ltda., Brazil (7)
Research Chemicals, U.S.A. (11)
Union Carbide Corporation, Linde Division, U.S.A. (3)

RE HANDBOOK

An attempt to combine and integrate as far as is practical the physics and chemistry of the rare earths has resulted in the publication of the first volume of a four-volume set entitled *Handbook on the Physics and Chemistry of the Rare Earths, Volume 1: Metals,* K. A. Gschneidner, Jr. and L. Eyring, eds., North Holland Publishing Co., Amsterdam (1978). The editors have invited experts in various areas to write comprehensive, broad, up-to-date and critical reviews. Volume 1 is concerned with the rare earth metals. Chapters and authors are listed below.

"Atomic properties (free atom)," Z. B. Goldschmidt
"Preparation and basic properties of the rare earth metals," B. J. Beaudry and K. A. Gschneidner, Jr.
"Electronic structure of rare earth metals," S. H. Liu
"Cerium," D. C. Koskenmaki and K. A. Gschneidner, Jr.
"Low temperature heat capacity of the rare earth metals," L. J. Sundstrom
"Magnetic and transport properties of the rare earths," K. A. McEwen
"Magnetic structures and inelastic neutron scattering: metals, alloys and compounds," S. K. Sinha
"Elastic and mechanical properties," T. E. Scott
"High pressure studies: metals, alloys and compounds," A. Jayaraman
"Superconductivity: metals, alloys and compounds," C. Probst and J. Wittig
"Kondo effect: alloys and compounds," M. B. Maple, L. E. DeLong and B. C. Sales
"Diffusion in rare earth metals," M. P. Dariel

Other features include the Prologue by F. H. Spedding, a list of contributors, and an extensive subject index. The book contains 894 pages and costs $130.00 (Dfl. 300). Subscription price is $112.50 (Dfl. 255).

Volume II, Alloys and Intermetallics is 620 pages in length, costs $85.00 (Dfl. 200) and is scheduled for publication later this year. Likewise, both *Volume III, Nonmetallic Compounds I* and *Volume IV, Nonmetallic Compounds II* are scheduled for publication this year

Re'ers Elected to NAE

Three rare earthers were among the 99 new United States members elected to the National Academy of Engineers (NAE) this year. They are H. G. Drickamer, University of Illinois, P. Duwez, California Institute of Technology, and J. A. Wernick, Bell Telephone Laboratories. Inclusion in this distinguished group is one of the highest forms of recognition accorded to American scientists and engineers.

Russian Books Acquired

Recently RIC has received several Russian volumes which include *Redkozemel'nye Poluprovodniki. Tekuschchaya Bibliograficheskaya Informatsiya 8* [*Rare Earth Semiconductors. Current Bibliographic Information, No. 8*], V. P. Zhuze, ed., Fiziko-Teknicheski Institut im. A. F. Ioffe, Akademii Nauk SSSR, Leningrad (1978), and also No. 9 which carries the same title, editor and publisher as No. 8. The eighth bibliography has 588 citations while the ninth has 646. References are printed in their original language and a brief subject index is included in each volume. Additionally we received *Redkozemel'nye Poluprovodniki* [*Rare Earth Semiconductors*], V. P. Zhuze and I. A. Smirnov, eds., Izdatel'stvo Nauka, Leningrad (1977). This book deals mainly with the semiconducting rare earth chalcogenides and oxychalcogenides.

The former costs $97.75 (Dfl. 220) and is 664 pages long while the latter costs $86.75 (Dfl. 195) and is 590 pages in length. Subscription prices for Volumes II, III and IV are $72.25 (Dfl. 170), $83.00 (Dfl. 187) and $73.75 (Dfl. 166), respectively. It is anticipated that this will become an open-ended set and that, subsequent to the release of Volume IV, supplements will be issued on a regular basis to keep the Handbook up-to-date.

For more information contact your bookseller or either of the following addresses.

Elsevier's Science Division
P. O. Box 211
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The Netherlands

Elsevier North-Holland, Inc.
52 Vanderbilt Avenue
New York, NY 10017, U.S.A.

Award to Drickamer

Case Western Reserve University, Cleveland, has announced the presentation of the Michelson / Morley award for an outstanding achievement by a scientist or engineer to H. G. Drickamer. Currently a professor of chemical engineering at the University of Illinois, Urbana, Drickamer is also the chairman of the National Research Council committee on ultrahigh pressure technology. He is being cited for the development of high-pressure techniques for the study of electronic states, electronic transitions and chemical changes. His current research interests include high pressure luminescence studies on phosphors doped with rare earths.

$Cu + Gd_2O_3$

A high conductivity and high specific heat copper-7.2% Gd_2O_3 composite has been developed for cryogenic applications according to W. A. Steyert [*J. Appl. Phys.* **49,** 3612-3 (1978)]. The Gd_2O_3 is an undissolved inclusion and does not contribute to either the electrical or thermal conductivity of the copper, however, near 4 K the specific heat of the composite is about 60 times larger than that of pure copper due to magnetic ordering in Gd_2O_3. Inexpensive methods of fabricating wares with residual resistance ratios greater than 1000 are proposed.

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K. A. Gschneidner, Jr. ...Editor
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What's the Difference?

It is hard for the average person to imagine what the difference is between 1 million bubbles and 4 million bubbles. However researchers at Bell Laboratories and International Business Machines (IBM) do know what the difference is and each, using a different technique, has managed to place 4 million magnetic bubbles into one square centimeter of a rare earth garnet thin film [*C &EN* **57,** [13] 25 (1979)]. Bell Laboratories has accomplished this by placing a layer of aluminum / copper alloy over the europium garnet film and then etching holes in the 0.25 μm Al layer. When electric current moves through the Al layer and around the holes a local magnetic field is created which attracts the magnetic bubbles in the garnet film and allows them to move from hole to hole. Smaller magnetic bubbles can be used resulting in the increased storage capacity.

IBM has accomplished the same increased storage capacity by adding a second garnet layer which contains gadolinium, placing gold circuit patterns over this layer and then bombarding the device with helium atoms. The helium atoms destroy the ability of the gadolinium garnet film to form bubbles except where the gold pattern was since gold absorbs helium. When an external field is applied charged walls are formed in the Gd garnet according to the gold circuit pattern. The magnetic bubbles in the Eu garnet film are attracted to the charged walls and are carried along the circuit in this manner.

RE Screens Affect Balance of Payments?

"Yes!" says R. A. Wilson [*Am. J. Roentgenology* **131,** 926-7 (1978)]. In addition to reducing X-ray exposure to patients, the rare earth screens allow a reduction of the silver content in the film. In some cases this amounts to 23% less silver used. The author notes that in the light of reduced silver production (increased imports), the current balance of payments, the scarcity of silver and the relative abundance of the rare earths, there is more benefit to be gained in the use of rare earth X-ray screens than just the reduction of patient exposure.

New Materials Award

B. T. Matthias of Bell Laboratories and the University of California, San Diego has been named one of three co-recipients of the American Physical Society's International Prize for New Materials. The three are being cited "for the discovery of intermetallic compounds and alloys exhibiting unusually high superconducting transition temperatures and for their demonstration that these materials retain their superconductivity under conditions of high currents and fields, thereby opening up the practical application of superconductivity to electric power technology and the magnetic confinement of plasma in future thermonuclear fusion reactors."

Matthias joined Bell Laboratories in 1948 and the University of California in 1961. In 1971 he was named director of the Institute for Pure and Applied Physical Sciences of the University of California, San Diego. Current interests include work on superconducting materials, many of which contain rare earths, and the coexistence of superconductivity and ferromagnetism.

LUTETIUM DISPLAY

Lutetium, long portrayed as the densest rare earth with little or no hope of useful application, may beat some of the allegedly less-dense rare earths to the market place according to M. M. Nicholson and R. V. Galiardi [*Soc. for Information Display '78 Digest,* pp. 24-5]. A lutetium diphthalocyanine complex has been deposited as a film and then inserted into an electrochemical cell. When different voltages are applied the complex varies in color from deep blue and violet through several shades of green to orange and red. Writing and erasure in this system occur in less than 50 ms with low input voltage and switching energy. Other desirable properties of this complex include a non-volatile memory, wide viewing angle, and good appearance in both low ambient light levels and direct sunlight. A variety of alphanumeric and graphic displays are possible applications.

SMOOTH REs

G. P. Sharonov and V. I. Tsyptsin have examined the use of rare earth diheptylphosphinates as lubricating oil additives to accelerate break-in and improve the wear resistance of machine parts [*Khim. i Teknol. Topliv i Masel* **1978,** No. 1, 44-9; Eng. Transl.-*Chem. Tech. Fuels and Oils* **14,** 53-9, (1978)]. They found that when oil with the rare earth complex was used the initial break-in of the machine parts was at least three times faster than with regular oil additives, the machine parts showed only one-sixth as much wear, and that a greater load could be applied to moving parts before seizure occurred. In analyzing the break-in process the authors concluded that initially the friction causes a chemical change converting the rare earth complex to rare earth and iron phosphides which have low friction coefficients and form a film on the moving surfaces and thereby reduce friction. This results in an increase in the seizure load. The final chemical modification results when the rare earth and iron phosphides react to form a ferrite which has a garnet structure on the surface of the moving parts. The garnet material is harder than the original alloy and provides greater wear resistance.

Increasingly Attractive

D. T. Curry is talking about rare earth-cobalt permanent magnets but not just about their magnetic properties [*Machine Design* **50,** No. 20, 94-9 (1978)]. Because of innovations in both product design and material composition many companies are taking a much closer look at the rare earth permanent magnets. Line printers, motors, alternators, window lifts, agitators, torque devices, servosystems, traveling-wave tubes, and tachometers are a few of the applications that many companies have either already incorporated the rare earth magnets into or begun programs to study the possibility of substituting the rare earth magnets for what they presently use. Several companies are examining mischmetal-cobalt magnets in an attempt to add low cost to the list of advantages which already includes superior magnetic properties and both reduced weight and volume requirements.

POWDER PREPARATION

In a study to develop a simple and expedient technique for consistently producing sinterable powders of lanthanide, hafnium and zirconium oxides, S. L. Dole, R. W. Scheidecker, L. E. Shiers, M. F. Berard and O. Hunter, Jr. have developed a procedure to produce powders which yield nearly theoretically dense specimens [*Materials Sci. and Eng.* **32,** 277-81 (1978)]. Water removal from the hydroxide precursor was determined to be the critical step in producing highly sinterable powders. An acetone wash removed most of the water and this was followed by a toluene wash which forced the remaining free water from the material. A final acetone bath prepared the material for drying. Sintering tests on Gd_2O_3, Er_2O_3, Y_2O_3, Sc_2O_3, Eu_2O_3, and HfO_2 or ZrO_2 stabilized by Pr_2O_3, Er_2O_3, Eu_2O_3, Y_2O_3, Tb_2O_3, or Gd_2O_3 consistently resulted in densities of 99% theoretical density. This is an improvement of from 3 to 5% over the typical densities of powders dried from aqueous mediums.

COOL REVIEW

Hyperfine enhanced nuclear magnetic cooling is the subject of a review by K. Andres [*Cryogenics* **18,** 473-7 (1978)]. Following a brief history of the origin of nuclear magnetic cooling, the physical principles involved in obtaining sufficiently high magnetic fields for hyperfine enhanced nuclear magnetic cooling are outlined. Pertinent properties of the praseodymium compounds, PrBi, $PrTl_3$, $PrCu_6$, $PrCu_2$, $PrCu_5$, $PrPt_5$, $PrNi_5$ and $PrBe_{13}$, are listed in tabular form. Praseodymium intermetallic compounds have the advantage of needing smaller magnetic fields to obtain larger cooling entropies per unit volume than other candidates. The author concludes that temperatures in the area of 100 μK are feasible if a way is found to shorten thermal relaxation times or if a two-stage cooling scheme can be developed.

MOTHER KNOWS BEST

In this case, Mother Nature knows best according to A. E. Ringwood, S. E. Kesson, N. G. Ware, W. Hibberson and A. Major who have developed a material for storing radioactive nuclear reactor wastes based on minerals in which they occur naturally [*Nature* **278,** 219-23 (1979)]. Apart from the human element involved in the production of nuclear energy, the major concern at present is the disposal of the radioactive wastes (of which the rare earth elements constitute approximately 26.4 Mol. %) in such a fashion as to insure that the radioactive materials do not leave the disposal site. Concern has arisen recently because of the discovery that under certain conditions the currently used glass encasement devitrifies allowing the water-soluble elements to escape. The present authors did not originate the idea of storing radioactive wastes in crystalline material, however they have developed a mixture of only three minerals, hollandite, perovskite, and zirconolite, and a process for incorporating the wastes which is comparable in cost to the current methods. Leaching of samples under 500 atm. pressure and up to 900°C in both pure water and 10% NaCl solutions resulted in no degradation of the mineral and no loss of the radioactive wastes.

Rare-Earth Information Center
Energy and Mineral Resources Research Institute
Iowa State University
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RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
IOWA STATE UNIVERSITY / AMES, IOWA

Volume XIV | September 1, 1979 | No. 3

14th RARE EARTH RESEARCH CONFERENCE

Incredible! Stupendous! Fantastic! Of course, we all know that these adjectives can be applied to any facet of rare earth research, but what brings them to mind at this time is the memory of the 14th Rare Earth Research Conference held June 25-28, 1979, on the campus of North Dakota State University in Fargo, North Dakota. Superb organization mixed liberally with hospitality and attention to details, e.g., fruit baskets in the rooms upon arrival, insured a relaxed atmosphere conducive to the exchange of ideas and information. The Conference attracted about 165 participants representing 18 countries including the United States. Some 30 students took advantage of the special registration fee—an encouraging sign for future rare earth research.

W. K. Zwicker (right) discussing laser materials during poster session.

About 150 papers were presented in both oral and poster sessions on the topics of spectroscopy (luminescence, fluorescence, laser, Mössbauer, ESR); metallurgy and materials preparation; solution, solvation and analytical chemistry; X-ray and neutron diffraction; transport and thermal properties; hydrides; magnetism, and rare earth technology. The proceedings of the Conference will be edited by G. J. McCarthy, J. J. Rhyne, and H. B. Silber and published as a book entitled *The Rare Earths in Modern Science and Technology, Volume 2* by Plenum Publishing Corporation. Information concerning the publication of the proceedings will be announced in the *RIC News* as soon as this information becomes available. A list of the papers presented at the Conference is available from RIC upon request.

E. Parthé presenting paper on crystal chemistry of rare earth alloys.

As with previous conferences, this one generated several firsts, the most significant being the creation and presentation of the Frank H. Spedding Award. Emeritus Professor Spedding from Iowa State University was on hand to present the award to its first recipient, Professor W. E. Wallace of the University of Pittsburgh. In addition, it was decided to permanently incorporate the Rare Earth Research Conference and to change the frequency of the conference to every two years.

Speaking of the next conference, the chairman, approximate date and location of the 15th Rare Earth Research Conference are W. J. James, June 1981 and Rolla, Missouri, respectively.

And finally, as is evidenced by several of the photographs accompanying this story, rare earth conferences are not totally taken up

(continued on page 3)

$$ 1980 $$

As the rare earth scientific community plunges into the 1980's with its promise of new and exciting discoveries, the rare earth industrial community has made preparations to meet the new and increased demands for rare earth materials if the first-quarter response for fiscal year 1980 is any indication. So far twenty-six companies have responded with those who were able to increase their support outnumbering the others by four to one. First-quarter contributors are listed below. The number in parentheses is the number of years the company has supported the Center.

Brown, Boveri & Company, Limited, Switzerland (8)
CERAC, Incorporated, U.S.A. (4)
Davison Specialty Chemical Co., Subsidiary of W. R. Grace & Co. U.S.A. (12)
Denison Mines Limited, Canada (8)
Ferro Corporation, Transelco Division, U.S.A. (4)
Foote Mineral Company, U.S.A. (8)
Th. Goldschmidt AG, Germany (11)
Hitachi Magnetics Corporation, U.S.A. (6)
Indian Rare Earths Ltd., India (11)
Inland Motor Division, Kollmorgan Corp., U.S.A. (4)
Kolon Trading Co., Inc., U.S.A. (7)
Lunex Company, U.S.A. (10)
MCI - Megon A.S., Norway (9)
Mitsubishi Chemical Industries, Limited, Japan (7)
Molycorp, Inc., U.S.A. (12)
Rare Earth Products Limited, England (8)
Reactive Metals & Alloys Corporation, U.S.A. (4)
Reactor Experiments, Inc., U.S.A. (10)
Rhone-Poulenc-Chimie Fine, France (10)

(continued on page 4)

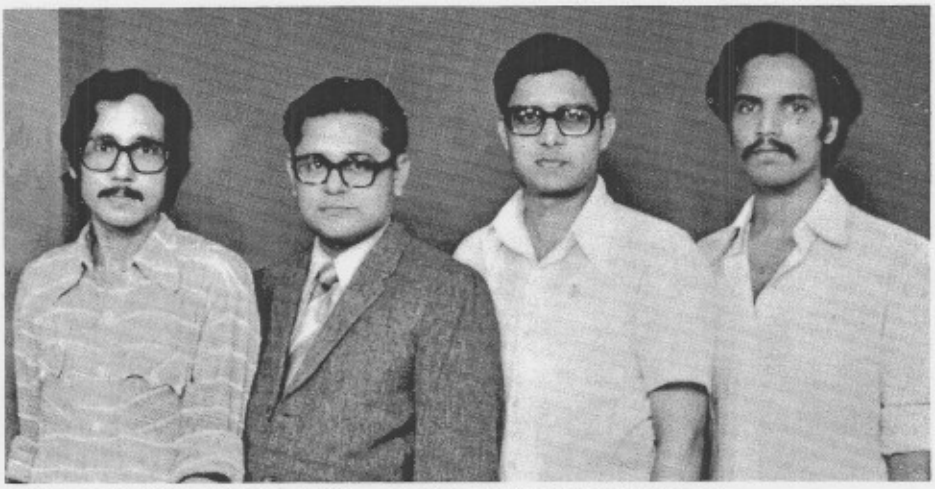
Ho

1879

Holmium joins scandium and samarium in celebrating its 100th anniversary of discovery in 1979. Holmium is actually a third-generation rare earth in that yttria was first discovered and then erbia was separated from the yttria. Finally, Swedish chemist P. T. Cleve noticed that the atomic weight of erbium was not constant and succeeded in separating erbia into erbia, thulia and holmia. Holmia is the Latinized name of Cleve's birthplace, Stockholm. The discovery of holmium does not belong solely to Cleve however. While examining the absorption spectra of erbia J.-L. Soret, a Swiss chemist, independently recognized the presence of a new "earth x" and characterized it by its absorption spectra. Later it became apparent that Soret's earth x and Cleve's holmia were one and the same and the name holmia was retained. Holmium has found application in phosphors and magnetic bubble garnet devices.

Amorphous Structure Effects

The origin and consequences of local couplings on the magnetic properties of amorphous alloys have been reviewed by R. W. Cochrane, R. Harris and M. J. Zuckermann [*Physics Reports* **48,** 1-63 (1978)]. The structure of amorphous metals is described and then related to the dense-random-packing-of-hard-spheres model. The experimental data for both soft and hard magnetic amorphous alloys are summarized. The main portion of the review is devoted to the HPZ theory of random magnetic anisotropy including electrostatic fields in amorphous systems and the crystal field Hamiltonian, magnetic properties of computer-generated clusters, mean field theory, and initial magnetization and hysteresis in spin glass-like states. Two recent applications of the random magnetic anisotropy model, the study of spin dynamics of amorphous ferromagnets and specific heat of amorphous rare earth-transition and noble metal alloys, are described.



Left to right: A. Rajput, R. Ramji, A. Ramanand and J.V.S.S. Narayanamurthy.

RARE EARTH RESEARCH IN INDIA

Indian Institute of Technology—

In 1971 Dr. R. Ramji Rao of the physics department of the Indian Institute of Technology, Madras 600036, India initiated studies on the elastic and thermal properties of the hexagonal-close-packed (HCP) rare earth metals (REM). The lattice dynamics of the metals Gd, Tb, Dy, Ho, Er, Tm, Lu, Sc and Y were investigated in order to study the lattice contribution to the specific heat. The analysis of the magnetic contribution to the specific heat of the heavy rare earth metals has been done by Mr. Ramanand and Mr. Narayanamurthy. Along with Dr. C. S. Menon, presently working in the physics department at the University of Calicut, Kerala, India, and Mr. Ramanand, Dr. Rao has studied the anharmonic properties of the rare earth metals, such as the thermal expansion, on the basis of third-order elastic constants (TOEC). All of the independent TOEC have been calculated and used to evaluate the pressure derivatives of the second-order elastic constants. The TOEC have also been applied to calculate the Anderson-Grüneisen parameter which is useful in determining the temperature dependence of the bulk modulus of the solid metals. Additionally, the changes in the lattice parameters and volume in all of the REM due to the application of hydrostatic pressure have been estimated using the TOEC data. Mr. Rajput and Mr. Narayanamurthy have been working on the calculation of the TOEC, thermal expansion and compression curves of Tm, Y, Sc, Nd and Pr, the latter two having the dhcp (double hexagonal close-packed) structure. The theoretical work done at the Indian Institute of Technology on the TOEC, low-temperature thermal expansion and compression of the rare earth metals has been useful because of the lack of experimental data in these areas. Future plans of the group include the investigation, in greater detail, of the thermodynamic properties of the dhcp rare earth metals.

POLISHING POWER

N. L. Kudryavtseva, N. E. Khar'kov, M. V. Bykov and G. S. Khodakov have undertaken an analysis of commercial glass polishing powders from America, England, France, Japan and West Germany to determine the composition, physical and chemical properties and to compare the polishing ability of each with that of Russian powders [*Opt. Mekh. Promst.* **45,** 41-4 (1978); Eng. Transl. - *Sov. J. Opt. Technol.* **45,** 306-8 (1978)]. The composition of the powders ranged from 100% CeO_2 to a solid solution of mixed rare earth oxides. Polishing abilities varied greatly but it was observed that the powders that contained some free CeO_2 had better polishing abilities than the powders which contained only a solid solution of mixed rare earth oxides. The amount of residual microstrains in the powder also influenced the polishing characteristics, the smaller the amount the better the polishing ability. None of the imported powders were observed to produce scratches or deposits on the glass surface.

14th R. E. Conference
(continued from page 1)

with the exchange of scientific information. On Wednesday evening Conference chairman Gruber was convinced by his associates to fill in and provide the promised entertainment—Indian dancing—and he

J. Cannon aiding local musicans.
Photo courtesy of E. Westrum

J. Gruber addressing attendees at Wednesday's fish fry after rain dance.
Photo courtesy of E. Westrum

performed a rain dance. However, several of the perpetrators were observed the next day being drenched by passing clouds and the next day's headline in a local Iowa newspaper read "Powerful Storm System Formed in North Dakota." It appears unwise to underestimate the abilities of a rare earth research conference chairman!

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K. A. Gschneidner, Jr. ...Editor
Bernie Evans...Staff Writer

Intermediate Valence

The current status of theoretical and experimental research on the intermediate valence, IV (or interconfigurational fluctuation, valence instability, mixed valence, fluctuating valence), problem is the subject of reviews by J. M. Robinson [*Physics Reports* **51,** 1-62 (1979)], and J. H. Jefferson and K. W. H. Stevens [*J. Phys. C* **11,** 3919-47 (1978)].

Robinson first reviews the experimental data obtained by X-ray optical, electrical, thermodynamic, neutron diffraction, magnetic susceptibility and Mössbauer resonance techniques for both rare earth and actinide IV materials. Various IV theories, including the Ramirez-Falicov-Kimball model, hybridized models, lattice change models, ground state theories and the atomic representation, are discussed. The author concludes that configuration-based treatments offer more hope for a detailed quantum mechanical description of the electronic states of these materials than do the single particle approximations.

Jefferson and Stevens concentrate on the theoretical aspects of the IV problem. After briefly examining experimental aspects, an "ideal" Hamiltonian is proposed. Current theories, such as a thermodynamic theory, microscopic theory, low energy states, hybridization and Green function methods, renormalization group methods and variational methods, are related to the "ideal" Hamiltonian. The parts of the IV problem that are not well understood are noted in addition to the areas where understanding is reasonably satisfactory. Finally, the authors put the IV problem into perspective by comparison with other narrow band phenomena such as the Kondo problem and the excitonic insulator.

Chalcogenide Valences

Data on the valence of samarium and thulium chalcogenides obtained from several different experimental methods have been reviewed by R. Suryanarayanan [*Phys. Stat. Solidi (b)* **85,** 9-43 (1978)]. A brief history of mixed valence studies is given along with preparation and characterization techniques for both bulk and film samples. Optical absorption spectra and electrical and magnetic property measurements pertaining to the valence question are presented for samarium and thulium monochalcogenides, their anion and cation substituted monochalcogenides and the Sm_2S_3-Sm_3S_4 system. Various theoretical models are presented.

Distinguished Professor

K. A. Gschneidner, Jr., was named a Distinguished Professor in Science and Humanities at a recent meeting of the faculty at Iowa State University in recognition of outstanding accomplishment as evidenced by superior ability and professional prominence. The title is accompanied by a plaque and a $500 honorarium and is retained by the recipient for the rest of his career. Gschneidner is currently the program director for Metallurgy and Ceramics at Ames Laboratory-DOE and director of the Rare-Earth Information Center. Current research interests include low-temperature heat capacity, magnetic susceptibility and electrical resistivity of rare earth alloys and superconductivity.

FRENCH RE CONFERENCE

The Proceedings of the International Conference on the Physics of the Metallic Rare Earths, St. Pierre-de-Chartreuse, France, September 4-7, 1978, have been published in *Journal de Physique (Paris) Supplement* **40,** C5-1-404, (1979). Sponsored by the Centre National de la Recherche Scientifique, the meeting attracted 216 participants from 22 countries. 144 papers were presented, 21 of which were invited. Topics ranged from physics, electronic structure, exchange interactions and crystal field effects, $3d$-$4f$ metallic compounds, metallic hydrides, valence instabilities, amorphous alloys and spin glasses to a review of applications.

The cost of the proceedings is 220 F.F. in France and 245 F.F. (~ $58.00) abroad and may be obtained by contacting: Journal de Physique
Z.I. de Courtaboeuf
B.P. 112
91402 Orsay, France

Z. Bieganski Dies

RIC has been informed of the untimely death of Dr. Z. Bieganski, who, at the age of 49, died as the result of a heart attack on May 4. Bieganski was educated at the Technical University of Wrocław, receiving a master's degree in chemistry in 1956 and his Ph.D. in chemistry in 1962. He was initially employed at the Technical University of Wrocław but then moved to the Institute for Low Temperature and Structure Research of the Polish Academy of Sciences where he was appointed as head of the Low Temperature Calorimetry Laboratory. Bieganski is best known in the rare earth community for his low-temperature heat capacity studies on the rare earth di- and trihydrides.

Business News

Rhone-Poulenc Expands

Citing substantial developments in industrial applications of the rare earths, Rhone-Poulenc-Chimie Fine of France has announced plans for increasing its capacity for separation and production of the rare earths. An increase in handling capacity from 8000 to 12,000 tons per year is scheduled for the ore-crushing and preparation plant at La Rochelle in western France. Additionally, Rhone-Poulenc's U.S. subsidiary in Freeport, Texas intends to add a rare earth processing plant to its current installation.

Mitsubishi + Megon

Fifty percent of A/S Megon has been purchased by Mitsubishi Chemical Industries and its name has been changed to MCI-Megon A.S. The company will continue to produce high-purity yttrium oxide at its plant at Kjeller, Norway. The plant's present capacity is 3 metric tons per year of yttrium oxide. New fields of application are expected to double the demand for Y_2O_3 in the near future.

Wako Bussan's 25TH!!

May 14, 1979 was a day for celebration for Wako Bussan Company Ltd., as it signified the twenty-fifth anniversary of the establishment of Wako Bussan in 1954. We congratulate them on their past success and wish them prosperity in the future.

NEW CRYSTAL SERIES

Rare earths have played a large part in the introduction of a new series of volumes by Springer-Verlag entitled *Crystals: Growth, Properties and Applications, Vol. 1 Crystals for Magnetic Applications* in that four of the five articles in Volume 1 deal with rare earth materials. The new series is designed to present critical reviews of recent developments in the theory, mechanisms and techniques of crystal growth. Edited by C. J. M. Rooijmans, Volume 1 was published in 1978, contains 139 pages and 79 illustrations and costs $29.00.

In the first article, W. Tolksdorf and F. Welz review the method of bottom growth for single crystals of yttrium iron garnets from high temperature solutions. A detailed description of materials, apparatus and procedures is given. 120 references are cited.

The state of the art of preparation of single crystal gadolinium garnets is reviewed by F. J. Bruni in the second article. Citing the rigid requirements of magnetic bubble devices, the author describes the sources and nature of crystal defects in addition to the growth techniques used to eliminate them. 49 references are cited.

A review of the liquid phase epitaxial growth of magnetic garnets by M. H. Randles constitutes the third article. Background, chemistry, apparatus and growth kinetics of the most successful technique for the growth of garnet films for bubble memory applications are presented. 103 references are cited.

The fourth article, by L. N. Demianets, reviews the hydrothermal crystallization of magnetic oxides including rare earth orthoferrites and garnets. Methods of obtaining both bulk single crystals and single crystal films are discussed. 74 references are cited.

$$ 1980 $$

(continued from page 1)

Ronson Metals Corporation, U.S.A. (12)
Santoku Metal Industry Co., Ltd., Japan (10)
Shin-Etsu Chemical Industry Co., Ltd., Japan (10)
V/O Techsnabexport, U.S.A. (3)
Treibacher Chemische Werke AG, Austria (8)
United States Radium Corporation, U.S.A. (10)
Wako Bussan Co., Ltd., Japan (11)

Special recognition is accorded to six companies this year for the part they have played in the success of the Rare-Earth Information Center. With this year's contribution they qualify for the RIC Honor Roll which signifies 10 years as a benefactor of the Center.

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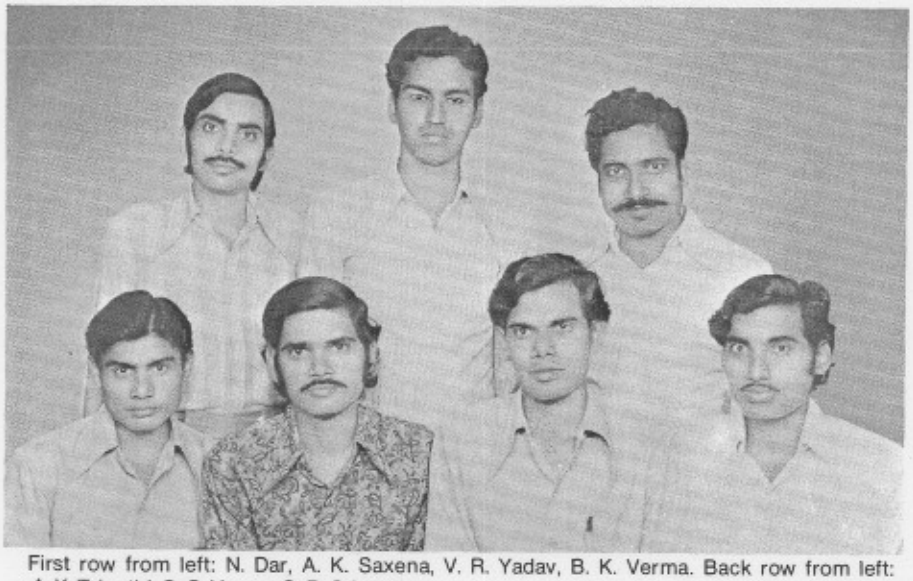
RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
IOWA STATE UNIVERSITY / AMES, IOWA

Volume XIV | December 1, 1979 | No. 4

RARE EARTH RESEARCH IN INDIA



First row from left: N. Dar, A. K. Saxena, V. R. Yadav, B. K. Verma. Back row from left: A. K. Tripathi, S. C. Verma, O. P. Srivastava

University of Gorakhpur—

H. B. Lal

Research work on rare-earth compounds was initiated in the Physics Department of Gorakhpur University, Gorakhpur, 273001 India, in 1971 under the leadership of Dr. H. B. Lal. This group started investigating the electrical transport and dielectric properties of rare earth compounds. The main aim of the study was to understand the physical mechanism involved in electrical transport and the nature of localized or bound charge carriers. Besides synthesizing and characterizing these compounds, the measurements being carried out are (i) D.C. electrical conductivity as a function of electric field, time and temperature, (ii) A.C. conductivity as a function of temperature and signal frequency, (iii) thermoelectric power as a function of temperature, (iv) dielectric constant as a function of frequency and temperature, and (v) magnetic susceptibility as a function of temperature. The group has published about forty papers including research notes on these compounds. The compounds studied in detail are rare earth sesquioxides (R_2O_3), rare earth tungstates $R_2(WO_4)_3$, $EuWO_4$, CeO_2, Pr_6O_{11} and Tb_4O_7. R_2O_3 compounds are found to be electronic conductors with positively charged intermediate polarons as the charge carrier. They conduct by the usual band mechanism but are dominantly scattered by optical phonons having band gaps varying from 2 to 3 eV in different R_2O_3. It has been found that light rare earth sequioxides show Curie-Weiss law behavior down to 4.2 K mainly due to crystal field, whereas heavier ones have ordered magnetic structures below 4.2 K. $R_2(WO_4)_3$ compounds (except R = Sm, Ce and Pr) are electronic conductors with intermediate polarons (holes) in O^{2-}: $2p$ band as the charge carrier. Conduction in Ce and Pr tungstates is due to intermediate polarons (electrons) in R^{3+}: $5d$ band. The conduction in CeO_2, Pr_6O_{11} and Tb_4O_7 is mainly due to impurities and defects. The main contributors to these studies are Drs. H. B. Lal, A. Kumar, N. Dar and Messrs. V. Pratap and B. K. Verma.

New research efforts are concerned with rare earth molybdates, chromates, garnets and zirconates. Messers S. C. Verma, V. Pratap and A. K. Tripathi are studying the magnetic susceptibility and D.C. conductivity of heavy rare earth molybdates. Similar work is being

(continued on page 4)

Contributors

Five companies renewed their support of the Center during the second quarter of fiscal year 1980. They are Allied Chemical Corporation (8), American Metallurgical Products Co. (11), Cometals, Inc. (3), Eastman Kodak Company (3) and Research Chemicals (12). All five are from the USA. The number in parentheses is the number of years each company has supported RIC. The total number of benefactors to date is now twenty-nine. To correct an error made in the September issue, we hereby report that V/O Techsnabexport is from the U.S.S.R. rather than the U.S.A. Sorry 'bout that!

Tm

1879

Thulium rounds out the foursome of rare earths that were discovered during the banner year of 1879 and share 1979 as their 100th birthday. Thulium, like holmium, is a third generation rare earth by way of yttria and erbia. Noticing anomalies in the atomic weight of what was then thought to be pure erbia, P. T. Cleve successfully separated the "pure erbia" into erbia, holmia and thulia. While Cleve had to share the discovery of holmia with the Swiss chemist, J.-L. Soret, he alone is given credit for the discovery of thulium. The word thulium is derived from Thule, an old name for Scandinavia. Applications of thulium include phosphors, ferrite bubble devices, catalysts and portable X-ray units.

NMR REVIEWED

M. A. H. McCausland and I. S. Mackenzie's review of the nuclear magnetic resonance (NMR) in rare earth metals, [*Advances in Physics* **28**, 305-456 (1979)], has appeal for both specialists and beginning students in the field of NMR spectroscopy. Several sections are devoted to introducing basic concepts such as Russell-Saunders coupling, spin-orbit splitting, magnetic dipole moments and the Zeeman interaction, electrical multipole moments and the crystal field interaction, hyperfine interactions in isolated ions, structural and magnetic properties of rare earth metals, alloys and compounds, and basic theory of rare earth magnetism. For the specialist, sections describe the dipole term, quadrupole term and second order effects of intra- and extra-ionic hyperfine interaction, nuclear energy levels and the NMR line spectrum, signs of hyperfine parameters, inhomogeneous broadening and satellite spectra, different NMR methods, NMR spectra and nuclear spin relaxation of rare earth metals, alloys and compounds. Areas where more NMR research is needed have been noted by the authors.

Bromides and Iodides

Book C6 of the *Gmelin Handbuch der Anorganischen Chemie, System 39, Rare Earth Elements* deals with compounds formed between Sc, Y and the lanthanides and bromine and iodine. Compounds covered include rare earth di- and tribromides, basic bromides, bromates, bromide-fluorides, alkali-bromometallates, di- and tri-iodides, basic iodides, iodates, periodates and alkali-iodometallates. Topics include preparation, crystallography, thermodynamic, chemical, optical and solution properties and complexes. Book C6 features an English table of contents, preface, margin notes, and a brief review at the beginning of each chapter. Published in 1978 by Springer-Verlag, this volume is 274 pages long and costs $352.70.

Business News

Mitsubishi + Megon

RIC incorrectly reported in the September 1, 1979 issue of the *RIC News* that Mitsubishi had purchased fifty percent of A/S Megon. Actually Mitsubishi and Megon have entered a joint venture for the production and sale of high purity yttrium oxide. A new company, MCI-Megon A.S., was formed to operate the facility at Kjeller, Norway, which was previously run by Megon. Megon and Mitsubishi each own fifty percent of the new company. The plant's present capacity is 30 metric tons (not 3 metric tons) of yttrium oxide per year.

Molycorp European Office

Molycorp, Inc. has announced the opening of a new European marketing and technical development base with the establishment of Molycorp International at 30, avenue George-V, 75008 Paris, France. Ir. H. E. Aldorf, formerly Assistant Sales Manager, Europe Chemicals, for Climax Molybdenum, will head up the new office as director of marketing.

Industry Profile

An extensive rare earth industry profile and market review has been presented in the March 1979 issue of *Industrial Minerals*, pp. 21-59. Lists of the major mineral producers and processors have been compiled and rare earth activities in Australia, Austria, Brazil, France, Germany, India, Japan, Malaysia, Norway, United Kingdom and the United States are discussed. Mineral sources are described and various market applications including flints, steel, permanent magnets, glass, phosphors, hydrogen storage, bubble devices, and catalysts are reviewed.

RE HANDBOOK

Volume 2: Alloys and Intermetallics of the *Handbook on the Physics and Chemistry of Rare Earths*, K. A. Gschneidner, Jr. and L. Eyring, eds., North-Holland Publishing Co., Amsterdam (1979) is now available. Volume 2 is 620 pages in length and costs $85.00 (Dfl. 200). Subscription price is $72.25 (Dfl. 170). Chapters and authors are listed below.

"Crystal Chemistry of intermetallic compounds," A. Iandelli and A. Palenzona

"Magnetic properties of intermetallic compounds of rare earth metals," H. R. Kirchmayr and C. A. Poldy

"Magnetostrictive RFe_2 intermetallic compounds," A. E. Clark

"Amorphous magnetic rare earth alloys," J. J. Rhyne

"Crystal fields," P. Fulde

"NMR, EPR and Mossbauer effect: metals, alloys and compounds," R. G. Barnes

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Liquid Metal Alloys

The magnetic properties of liquid metal alloys is the subject of a review by N. H. March and C. M. Sayers [*Advances in Physics* **28**, 1-47 (1979)]. Rare earth alloys are only briefly discussed while rare earth-transition metal liquid alloys are covered in detail, specifically alloys of La, Ce, and Pr with Co and Ni. Topics include magnetic susceptibility as a function of composition, density of states, partial structure factors and theory. Only two sections of the review are concerned with rare earth materials.

CAST IRON CONTROL

Control of the particles and precipitates formed in cast iron and their effects on the structure of cast iron are the subjects of a paper by W. G. Wilson that was presented at the 83rd Casting Congress of the American Foundrymen's Society, Birmingham, Alabama, May 1979. Wilson has used available thermochemical data, phase diagrams, etc. to develop a systematic method for controlling the precipitates. Copies of the paper may be obtained from Reactive Metals and Alloys Corporation, P.O. Box 366, Route 168, West Pittsburgh, PA 16160.

PHYSICS SYMPOSIUM

An international symposium on the Physics of Actinides and Related 4*f* Materials will be held April 9-11, 1980 at Zurich, Switzerland. Papers on 4*f* materials will be accepted if a relationship to the actinides can be clearly demonstrated. The symposium is open to anyone and will consist of invited and contributed papers dealing with bulk magnetic and related properties, lattice effects, mircoscopic magnetic measurements, electronic structure and associated properties. The application and abstract deadline is January 10, 1980 with papers being due March 10, 1980. The proceedings will be published by North-Holland Publishing Company as a special volume of *Physica B*. For more information contact B. Reihl, Laboratorium für Festkörperphysik, ETH Hönggerberg, CH-8093 Zürich, Switzerland.

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Berzelius' 200th

Photo courtesy of the Swedish National Museum, Dept. of Royal Castles' Collections.

(Editor's note: This is one of a continuing series of articles commemorating the centennials of those scientists who made great contributions to the field of rare earths.)

In addition to being the year in which the first Frank H. Spedding Award was presented and the 100th anniversary of the year in which four rare earths, Sc, Sm, Ho, and Tm, were discovered, 1979 has the further distinction of being the 200th anniversary of the birth of Jöns Jacob Berzelius, one of the founders of chemistry as we know it today.

Born on August 20, 1779, into a humble lifestyle, Berzelius lost both of his parents while he was still quite young. Two individuals, his stepfather Pastor Ekmarck and his natural history school teacher Dr. Hornstedt, instilled in young Berzelius an inquisitiveness and love of nature that was to guide his future development towards science at the expense of his Hebrew and church history studies. In 1802 he graduated with a degree in medicine, but even then most of his free time was spent on his chemistry experiments. His diligence and attention to detail paid off very quickly when, in 1803, Wilhelm Hisinger gave Berzelius a sample of Bastnäs tungsten ore to analyze. Hisinger thought the tungsten ore might contain some of the yttrium earth that Gadolin had discovered in a different ore in 1794. By autumn, both Berzelius and Hisinger were convinced that they had found a new element and named it cerium after the asteroid Ceres. Controversy followed the announcement when it was learned that a German scientist, M. H. Klaproth, had simultaneously made the same discovery, naming it ochroit earth, and Swedish professor Johan Afzelius claimed that cerium did not exist but was in fact a mixture of several known oxides. Berzelius persisted and was able to convince his colleagues of the validity of his discovery which he shares with Hisinger and Klaproth. After a minor stumble (the discovery of Gahnium, later found to be zinc oxide) Berzelius' career was off to the races. Contributions to the science of chemistry include calculation of the atomic weights of many of the elements that were known at that time, definitive work on the combining proportions of the elements, the discovery of selenium and thorium, and perhaps most notable, his system of chemical symbols to describe the elements and their compounds. Perhaps less auspicious but no less useful to the chemist are Berzelius' contributions to the laboratory, which include the desiccator, filter paper, rubber tubing, the wash bottle and the water bath.

4th RE-Co Workshop

The *Proceedings of the Fourth International Workshop on Rare Earth-Cobalt Permanent Magnets and Their Applications,* held May 22-24, 1979 at Hakone National Park, Japan, are now available as a 450-page paperbound volume for $25.00, plus $6.00 per copy for overseas delivery from the Society of Non-Traditional Technology, Kotohira Kaikan Bldg. No. 2-8, 1-Chome, Taranomon, Minato-ku, Tokyo 105, Japan. Residents of the USA, Canada and Mexico may obtain copies for $25.00, plus $3.00 postage from the Magnetics Laboratory, KL-365, University of Dayton, Dayton, Ohio 45469. Forty-seven articles outline electrical applications, medical applications, magnetic bearings and other mechanical devices, magnetic properties, magnetic aftereffects, structure and coercivity and permanent magnet materials.

e: Key Elements: d^9-, d^{10}-, $d^1..d^3$-, f-elements, edited by K.-H. Hellwege and A. M. Hellwege has been published by Springer-Verlag (1976). The cloth-bound volume is 739 pages in length and costs $278.00 (DM680).

Data is arranged in tables and includes the chemical formula, space group, lattice constants, number of formula units per unit cell, density, structure type, scope of structural determination, the method used and references. Oxo-compounds of scandium, yttrium, and the lanthanides (La-Lu, except Pm); hydroxo-compounds of scandium, ytterbium and lutetium and flurooxo-compounds of cerium are included. This volume also contains data for similar compounds of Cu, Ag, Au, Zr, Cd, Hg, the actinides, Ti, Zr, Hf, V, Nb and Ta.

24th MMM Proceedings

The proceedings of the 24th Annual Conference on Magnetism and Magnetic Materials, November 14-18, 1978, Cleveland, Ohio, edited by J. J. Becker and J. C. Bonner, has been published by the American Institute of Physics in the *Journal of Applied Physics* **50,** 1551-2464 (1979). Over 40% of the 320+ articles are concerned with rare earth materials. Topics covered include metallic glasses, amorphous rare earth-transition metal alloys, anisotropy and magnetostriction of crystalline and amorphous materials, spin glasses, electronic structure, exchange interaction, critical behavior, superconductivity, magnetic structure, transport, insulators, semiconductors, neutron scattering, hydrides, garnets, magnetic domains, bubble materials, intermetallic compounds, hard magnetic materials, phonon-magnon interaction and microwave devices.

nent magnet alloys; low-samarium (Ce-based R-Co-Cu and $MMCo_5$) magnet materials; flexible, plastic-bonded R-Co permanent magnets; new standards in commercial magnet applications; the situation of R-Co magnets in Japan; applications in electrical machines of medium to large power ratings and virtually zero-powered magnetic bearings for high-vacuum operation; and methods for chemical and physical analysis of powdered R-Co magnets and alloys. An appendix contains phase diagram data for binary and ternary alloys between the rare earths La, Ce, Sm and MM and the transition metals Fe, Co and Cu.

Copies can be obtained by writing to: Th. Goldschmidt Prod. Corp., 175 Main Street, White Plains, NY 10601, U.S.A.

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O. P. Srivastava is studying the transport mechanisms in ZrO_2:R_2O_3 systems in order to obtain a high temperature solid electrolyte, which may have application as solid superionic conductors.

The encouragement, active interest and help provided by Prof. N. K. Sanyal, Head of the Physics Department, University of Gorakhpur and SIDA, Sweden, are the keys to the success of our work.

TOXICITY

A review concerned with new aspects of the toxicity of the rare earths has been compiled by P. Arvela [*Progress in Pharmacology* **2,** [3] 69-112 (1979)]. A brief mention of the physical and chemical properties, natural occurence and applications of the rare earths is made. Topics covered more extensively include metabolism, distribution, excretion, acute and chronic toxicity, effects as calcium antagonists, effects on microsomal drug metabolism, secretory processes, interaction with mitochondria and the effects of other agents on the toxicity of the lanthanides. The rare earths were found to be essentially nontoxic when taken orally due to limited intestinal absorption. However, inhalation of rare earth particles is hazardous to the lungs. Two hundred and thirty references are cited.